The gas occluded by iron, from a carbonaceous fire, is very different, the prevailing gas then being carbonic oxide. For comparison a quantity of clean horseshoe nails was submitted to a similar distillation. The gas collected from 23·5 grammes of metal (3·01 cub. centims.) was—

In 150 minutes	5·40 cub. centims.
In 120 minutes	2·58 ,,
In 4 hours 30 minutes......................	7·98 ,,

The metal has given 2·66 times its volume of gas. The first portion collected appeared to contain of hydrogen 35 per cent., of carbonic oxide 50·3, of carbonic acid 7·7, and of nitrogen 7 per cent. The latter portion collected gave more carbonic oxide (58 per cent.) with less hydrogen (21 per cent.), no carbonic acid, the remainder nitrogen. The predominance of carbonic oxide in its occluded gases appears to attest the telluric origin of iron.

Hydrogen has been recognized in the spectrum-analysis of the light of the fixed stars, by Messrs. Huggins and Miller. The same gas constitutes, according to the wide researches of Father Secchi, the principal element of a numerous class of stars, of which α Lyræ is the type. The iron of Lenarto has no doubt come from such an atmosphere, in which hydrogen greatly prevailed. This meteorite may be looked upon as holding imprisoned within it, and bearing to us hydrogen of the stars.

It has been found difficult, on trial, to impregnate malleable iron with more than an equal volume of hydrogen, under the pressure of our atmosphere. Now the meteoric iron gave up about three times that amount, without being fully exhausted. The inference is that the meteorite has been extruded from a dense atmosphere of hydrogen gas, for which we must look beyond the light cometary matter floating about within the limits of the solar system.

V. "Further Observations on the Structure and Affinities of *Eozoon Canadense*." In a Letter to the President. By William B. Carpenter, M.D., F.R.S., F.L.S., F.G.S. Received May 9, 1867.

University of London, May 9th, 1867.

When, on the 14th of December 1864, I addressed you on the subject of the remarkable discovery which had been recently made in Canada, and submitted by Sir William Logan to myself for verification, of a fossil belonging to the Foraminiferal type, occurring in large masses in the Serpentine-limestones intercalated among Gneissic and other rocks in the Lower Laurentian formation, and therefore long anterior in Geological time to the earliest traces of life previously observed, no doubts had been expressed as to the *organic* nature of this body, which had received the designation *Eozoon Canadense*.

The announcement was soon afterwards made, that the Serpentine Marble of Connemara, employed as an ornamental marble by builders

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under the name of "Irish Green," presented structural characters sufficiently allied to those of the Laurentian Serpentines of Canada, to justify its being referred to the same origin. An examination of numerous decalcified specimens of this rock led me to the conclusion, that although the evidences of its organic origin were by no means such as to justify, or even to suggest, such a doctrine, if the structure of the Canadian Eozoon had not been previously elucidated, yet that the very exact correspondence in size and mode of aggregation between the Serpentine-granules of the Connemara Marble and those of the 'acervuline' portion of the Canadian, was sufficient to justify in behalf of the one the claim which had been freely conceded in regard to the other.

In the following summer, however, it was announced in the 'Reader' (June 10, 1865) by Professors King and Rowney of Queen's College, Galway, that having applied themselves to the study of the Serpentine Marble of Connemara with a full belief in its organic origin, they had been gradually led to the conviction that its structure was the result of chemical and physical agencies alone, and that the same explanation was applicable to the supposed *Eozoon Canadense* of the Laurentian Serpentines. This view was afterwards fully set forth in a Paper "On the so-called Eozoonal Rock," read at the Geological Society on the 10th of January 1866, and published (with additions) in the Quarterly Journal of the Geological Society for August 1866. The following is their own Summary of their conclusions (p. 215):—"It has been seen (1) that the 'chamber-casts' or granules of serpentine are more or less simulated by chondrodite, coccolite, pargasite, &c., also by the botryoidal configurations common in Permian Magnesian Limestone; (2) that the 'intermediate skeleton' is closely represented, both in chemical composition and other conditions, by the matrix of the above and other minerals; (3) that the 'proper wall' is structurally identical with the asbestiform layer which frequently invests the grains of chondrodite—that, instead of belonging to the skeleton, as must be the case on the eozoonal view, it is altogether independent of that part, and forms, on the contrary, an integral portion of the serpentine constituting the 'chamber-casts,' under the allomorphic form of chrysotile, and that perfectly genuine specimens of it, completely simulating *casts* of separated nummuline tubules, occur in true fissures of the serpentine-granules; (4) that the 'canal-system' is analogous to the imbedded crystallizations of native silver and other similarly conditioned minerals, also to the coralloids imbedded in Permian Magnesian Limestone; that its typical Grenville form occurs as metaxite, a chemically identical mineral imbedded in saccharoidal calcite; (5) that the type examples of 'casts of stolon-passages' are isolated crystals apparently of pyrosclerite. Furthermore, considering that there has been a complete failure to explain the characters of the so-called internal casts of the 'pseudopodial tubules' and other 'passages' on the hypothesis of ordinary mechanical or chemical infiltration, also bearing in mind the significant fact that the 'intermediate skeleton,' in Irish and other varieties of eozoonal rock, contains modified examples of the 'definite shapes' more or less resembling the crystalline aggregations and prismatic lumps in primary saccharoidal marbles—that eozoonal structure is only found in metamorphic rocks belonging to widely separated geological systems, never in their unaltered sedimentary deposits,—taking all these points into consideration, also the arguments and other evidences contained in the present memoir, we feel the conclusion to be fully established, that every one of the specialities which have been diagnosed for *Eozoon Canadense* is solely and purely of crystalline origin: in short, we hold, without the least reservation, that from every available standing point—foraminiferal, mineralogical, chemical, and geological—the opposite view has been shown to be utterly untenable."

Considering that the Foraminiferal characters of *Eozoon Canadense* had been unhesitatingly accepted by all those zoologists, Continental as well as British, whose special acquaintance with the group gave weight to their opinion, it might have been prudent, as well as becoming, on the part of the Galway Professors, to express themselves somewhat less confidently in regard to its purely mineral origin. The case they made out would not have lost any of its real strength, if they had simply put forward their facts as affording valid grounds for *questioning* the received doctrine. And a way of escape would have been left for them, if the progress of research should happen to bring to light conclusive evidence on the other side.

Although such conclusive evidence is now producible, it may be well for me briefly to point out what I regard as the fundamental fallacies in the argument of Professors King and Rowney.

In the first place, the Serpentine-Marble of Connemara, on which their investigations had been chiefly conducted, is admitted by every one who has examined it to have undergone a considerable amount of metamorphic change. To myself, as well as to Professors King and Rowney, the evidence which it presents of the operation of chemical and physical agencies is most obvious and conclusive; whilst the evidence of its organic origin rests entirely on its partial analogy to the eozoonal rock of Canada. Hence an entire surrender might be made of the organic hypothesis as regards the Connemara marble, without in the least degree invalidating the claim of the eozoonal rock of Canada to an organic origin. But, on the other hand, if the latter claim can be sustained, it may be fairly extended to the "Irish Green," should the evidence of similarity be found sufficient to justify such an extension; since it must be admitted by every Petrologist, that no amount of purely mineral arrangement in a Metamorphic rock can disprove its claim to Organic origin, if that claim can be shown to be justified by distinct traces, in other parts of the same formation, of organisms adequate to its production. The Carboniferous Limestone, various members of the Oolitic and Cretaceous formations, and the Hippurite and Nummulitic Limestones, all exhibit in parts an entire absence of organic structure, which is yet so distinct elsewhere, as to justify the generalization that their materials have been originally separated from the ocean-waters by animal agency. And it is well known to those who have studied the changes which recent Coral-formations have undergone when upraised above the sea-level, that a complete conversion of a mass of Coral into a sub-crystalline Limestone not distinguishable from ordinary Carboniferous Limestone, may take place under circumstances in no way extraordinary.

It is, therefore, upon the character of the Serpentine-Limestone of *Canada*, not upon the nature of the Connemara Marble, that the question of organic origin entirely turns; and, as I have elsewhere shown in detail*, the hypothesis of Professors King and Rowney altogether fails to account for the *combination of phenomena* which the former presents, whilst the accordance of that combination with the idea of its Organic origin (a very moderate allowance being made for the effects of metamorphic change) is such as to establish the same kind of probability in its favour, as that which we derive in the case of the Human origin of the "flint implements" from the cumulative evidence of their succession of fractured surfaces, or in the case of the chemical composition of the sun from the precise correspondence between certain dark lines in the solar spectrum and groups of bright lines produced in a dark spectrum by the combustion of certain known metals.

I may stop to point out, however, that Professors King and Rowney do not attempt to offer any feasible explanation of the fundamental fact of the regular alternation of lamellæ of Calcareous and Siliceous minerals, often amounting to fifty or more of each kind, extending through a great range of area; nor of the fact that not only is this arrangement the same, though the siliceous mineral may be Serpentine in one place, Pyroxene in another, or Loganite in another, whilst the calcareous may be Calcite in one part, and Dolomite in another,—but that these variations may occur in one and the same specimen, the structural arrangement being continuous throughout.

And in what they state of the peculiar lamella forming the proper wall of the chambers, which I have designated the "nummuline layer," they have fallen into errors of fact so remarkable, that I can only account for them by the belief that when their paper was written they knew this layer only by decalcified specimens, and had never seen it in thin transparent sections. For they describe it as composed of parallel fibres of chrysotile packed together without any intermediate substance; whereas I have distinctly proved that the siliceous fibres are imbedded in a calcareous matrix; which I therefore feel justified in regarding as a finely tubulated Nummuline shell, of which the tubuli that were originally occupied by pseudopodia have been permeated by siliceous infiltration.

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* Quarterly Journal of the Geological Society, August, 1866.

So, again, while asserting that by no conceivable process could the animal substance originally occupying these tubuli have been replaced by siliceous minerals, they have entirely ignored the fact stated by me, that this very replacement has taken place in recent specimens in my possession,—a fact on the basis of which the reconstruction of the animal of Eozoon proposed by Dr. Dawson and myself securely rests.

The question may now, I believe, be regarded as conclusively settled by the recent discovery, in a sedimentary limestone of the Lower Laurentian formation at Tudor in Canada, of a specimen of *Eozoon* presenting characters that cannot, in the opinion of the most experienced Palæontologists and Mineralogists, be accounted for on any other hypothesis than that of its organic origin. For in the first place, the occurrence of a calcareous framework or skeleton in a matrix of sedimentary limestone, which also fills up its interspaces, altogether excludes the hypothesis that this framework might be the product of any kind of pseudomorphic arrangement produced by the separation of calcareous and siliceous minerals from a solution containing both. And, secondly, this specimen exhibits that which had not previously been distinctly seen in any other, viz., a distinctly limited contour, formed by the curving downwards and closing-in of the septa, in a manner as perfect and characteristic as the closing-in of the successive chambers of any polythalamous shell. I believe that no Palæontologist familiar with Palæozoic fossils would have hesitated to pronounce this specimen a Fossil Coral allied to *Stromatopora,* if it had occurred in a Silurian Limestone.

That this specimen, though differing greatly in appearance from the ordinary serpentinous *Eozoon*, really represents that organism, is shown not merely by the general arrangement of the calcareous lamellæ, but by their minute structure. This, it is true, is far less characteristically seen in thin sections microscopically examined, than it is in the specimens whose cavities have been filled up by Serpentine; the texture of which is often so marvellously little changed, as to have all the appearance of recent shell-substance. But the alteration which the shelly layers have undergone in this specimen, is precisely paralleled by that which I have been accustomed to find in the best-preserved specimens of other organic structures contained in the more ancient Limestones. And there are still distinctly-recognizable traces of the canal-system imperfectly injected with black substance, which correspond with those of the ordinary Serpentinous *Eozoon.*

For the imperfection of the specimen in this respect, however, full compensation is made in the perfect preservation of the canal-system in a small fragment of *Eozoon* long since observed by Dr. Dawson in a crystalline limestone at Madoc. This specimen having been placed in my hands by Sir William Logan, with permission to treat it in any way that should enable me to make a thorough examination of it, I have succeeded in finding in it most complete and beautiful examples of the canal-system, presenting varieties of size and distribution exactly parallel to those with which I am familiar in the Serpentine-specimens. Now as there is not in the Madoc, any more than in the Tudor specimen, any such combination of different minerals as has been supposed by Professors King and Rowney to have given origin to the arborescent forms of the canal-system of Eozoon (which they have likened to moss-agate or crystallized silver), there can be no longer any reasonable ground for disputing the essential similarity of this canal-system to that first described by myself in *Calcarina*, with which it was originally compared by Dr. Dawson*.

The extension of the inquiry into the character of the Serpentine limestones intercalated among the Gneissic and other rocks of Laurentian age in various parts of Europe, has brought to light such numerous examples of eozoonal structure, more or less distinctly preserved, as to afford strong grounds for the conclusion that this organism was very generally diffused at that epoch, and performed much the same part in raising up solid structures in the waters of the ocean, that the Coral-forming Zoophytes perform at the present time. I had myself examined before the close of 1865 specimens of Ophicalcite from Cesha Lipa in Bohemia and from the neighbourhood of Moldau, in which an eozoonal structure was distinctly traceable; and early in 1866 a more extended series was transmitted to me through Sir C. Lyell from Dr. Gümbel, the Government Geologist of Bavaria, in which I was able to trace a continuous gradation from specimens in which the eozoonal structure was distinct, to others in which, if it ever existed, it had been completely obscured by subsequent metamorphism. The results of a very careful and complete examination of the Ophicalcites of Bavaria by Dr. Gümbel himself has been communicated to the Royal Academy of Munich†.

Appearances of the same character are presented by a series of specimens of the Serpentinous Limestones from the Primitive Gneiss of Scandinavia, kindly transmitted to me by Prof Lovén.

I venture to hope that the foregoing *résumé* of the present aspect of this subject will be of interest to the Fellows of the Royal Society. I say the *present* aspect, because I am strongly convinced that we are at present only at the beginning of our knowledge of this and other ancient types of Foraminiferal structure; and that careful search in promising localities will bring to light many wonders now lying unsuspected in the vast aggregate of pre-Silurian strata.

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* A full description of these specimens by Dr. Dawson, with a notice of their stratigraphical position by Sir William Logan, has been read at the Geological Society on the 8th of May, 1867.

† "Ueber das Vorkommen von Eozoon im ostbayerischen Urgebirge," aus d. Sitzungsber. d. k. Acad. d. W. in München, 1866, i. 1.